

War and wildlife: linking armed conflict to conservation

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Armed conflict throughout the world's biodiversity hotspots poses a critical threat to conservation efforts. To date, research and policy have focused more on the ultimate outcomes of conflict for wildlife rather than on the ecological, social, and economic processes that create those outcomes. Yet the militarization that accompanies armed conflict, as well as consequent changes in governance, economies, and human settlement, has diverse influences on wildlife populations and habitats. To better understand these complex dynamics, we summarized 144 case studies from around the world and identified 24 distinct pathways linking armed conflict to wildlife outcomes. The most commonly cited pathways reflect changes to institutional and socio-economic factors, rather than tactical aspects of conflict. Marked differences in the most salient pathways emerge across geographic regions and wildlife taxa. Our review demonstrates that mitigating the negative effects of conflict on biodiversity conservation requires a nuanced understanding of the ways in which conflict affects wildlife populations and communities.

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Armed conflicts have occurred in more than two-thirds of the world's biodiversity hotspots over the past six decades (Hanson *et al.* 2009). Widespread and recurrent conflict presents a major challenge for wildlife that is not typically addressed by traditional conservation strategies. Many of today's conflicts are protracted, with long-lasting environmental consequences; as of 2014, 70% of active conflicts had begun before 2000 (Gleditsch *et al.* 2002; Pettersson and Wallenstein 2015). Given the increasing duration of present-day conflicts and unprecedented societal changes, ecologists and conservationists

must urgently acknowledge the many complex pathways that link conflict to wildlife habitats and populations.

A growing literature examines environmental change associated with armed conflict (Douglas and Alie 2014), and many case studies document the effects on wildlife habitats and populations (Dudley *et al.* 2002; Shambaugh *et al.* 2001). However, relatively little research and associated policy has focused on understanding or mitigating the underlying pathways between conflict and wildlife (Machlis and Hanson 2008). Armed conflict affects wildlife through a range of interactions, including tactical military operations, the displacement of people, and the interruption of food supply systems. Detailed analyses of these and other potential pathways, the contexts in which they are most common, and the outcomes for wildlife are essential to achieve effective biodiversity conservation. Such investigation is not only important during and after conflict but also critical to developing conservation strategies in peacetime, which can be sustained during potential future conflicts.

We conducted a comprehensive literature review to elucidate the outcomes of armed conflict for wildlife and to understand pathways through which these outcomes are mediated. Our systematic search of academic and gray literature identified 144 case studies from around the world that document the effects of armed conflicts on wildlife (WebPanel 1 and WebTable 1). We performed a content analysis of all case studies, and classified all pathways that were mentioned as a mechanism through which the conflict affected wildlife. Given the paucity of data in conflict areas and the complexity of these pathways and their interactions, few studies explicitly tested cause and effect. We were therefore liberal in our inclusion of pathways, recording all pathways that were suggested by data trends, interviews and surveys, or anecdotal evidence.

In a nutshell:

- Armed conflict has a largely detrimental effect on wildlife habitat and populations through tactical military strategies and effects on institutions, movement of people, and economies
- The most common pathways linking conflict to wildlife arise from institutional and socioeconomic changes associated with conflict, rather than directly from military tactics
- Conflict generates complex social and environmental dynamics over space and time, and the effects of conflict on wildlife differ across regions and taxa
- Because armed conflict frequently overlaps with biodiversity hotspots, an improved understanding of the links between armed conflict and wildlife can help to inform effective long-term management and conservation

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Table 1. Pathways through which armed conflict affects wildlife

<i>Tactical pathways</i>	<i>Wildlife effect</i>	<i>Direct or indirect</i>	<i># of cases</i>
<i>Military tactics</i>			81
1. Mines, bombs, and chemicals kill wildlife	–	<i>Direct, wildlife</i>	30
2. Environment damaged as a war tactic	–	<i>Direct, habitat</i>	23
3. Habitat created as byproduct of war tactic	+	<i>Indirect</i>	2
4. Protected areas used as staging grounds	–	<i>Indirect</i>	16
5. Increase in arms availability	–	<i>Indirect</i>	29
6. Decrease in arms availability	+	<i>Indirect</i>	4
<i>Supporting military activities</i>			48
7. High-value wildlife products finance war	–	<i>Direct, wildlife</i>	19
8. Wildlife to feed combatants	–	<i>Direct, wildlife</i>	27
9. Politicized killing of wildlife	–	<i>Direct, wildlife</i>	11
10. Politicized conservation of wildlife	+	<i>Indirect</i>	6
<i>Non-tactical pathways</i>			
<i>Changing institutional dynamics</i>			83
11. Enforcement abilities decrease	–	<i>Indirect</i>	67
12. International support withdrawn	–	<i>Indirect</i>	21
13. Conservation and research activities decline	–	<i>Indirect</i>	44
14. Traditional resource management weakened	–	<i>Indirect</i>	34
<i>Movement of people</i>			81
15. Displaced people kill wildlife for food	–	<i>Direct, wildlife</i>	34
16. Displaced people harvest natural resources	–	<i>Direct, habitat</i>	42
17. Refugee camps put pressure on resources	–	<i>Indirect</i>	27
18. Refuge effect (people avoid conflict areas)	+	<i>Indirect</i>	35
<i>Altered economies and livelihoods</i>			84
19. New trade routes for wildlife, natural resources	–	<i>Indirect</i>	28
20. Trade routes for wildlife, natural resources close	+	<i>Indirect</i>	8
21. Extractive industries decline	+	<i>Direct, habitat</i>	18
22. Extractive industries expand	–	<i>Direct, habitat</i>	33
23. Decline in agriculture and commerce increases natural resource demand	–	<i>Direct, wildlife and habitat</i>	35
24. Decrease in conservation/ecotourism livelihoods	–	<i>Indirect</i>	16

■ Links between armed conflict and wildlife

Our content analysis revealed 24 distinct pathways linking armed conflict to wildlife outcomes (Table 1). We organized these pathways thematically: 10 “tactical” pathways arise directly from the conflicts themselves and are associated with military tactics or supporting military activities (Figure 1a; Figure 2). The remaining 14 “non-tactical” pathways stem from broad sociopolitical and economic changes associated with armed conflict, including changing institutional dynamics, movement of people, and altered economies and livelihoods (Figure 1, b–d; Figure 2).

These pathways have diverse effects on wildlife populations and habitats. The 10 direct pathways result in the

death of non-human animals or the destruction or creation of habitat. The other 14 pathways affect wildlife indirectly, creating circumstances that enable easier or more profitable wildlife killing, habitat destruction, or conservation. Below, we explore these pathways and consider examples from the literature.

Military tactics

As armies and militias mobilize troops and resources, strategic military tactics can directly affect wildlife. Many forms of weaponry, including mines, explosives, and chemicals, can inadvertently kill animals, such as



Figure 1. (a) Tactical and (b–d) non-tactical pathways linking armed conflict to wildlife outcomes: (a) supporting military activities, (b) changing institutional dynamics, (c) movement of people, and (d) altered economies and livelihoods.

mountain gorillas (*Gorilla gorilla beringei*) in Rwanda (Kanyambwa 1998) and African elephants (*Loxodonta africana*) in Angola (Chase and Griffin 2011). War materials can linger in the environment and have lasting effects on wildlife, as occurred after Iraqi military forces deliberately set fire to hundreds of oil wells in the Persian Gulf region, devastating marine fauna (Gerges 1993). Soldiers may also intentionally destroy or alter wildlife habitats to gain battlefield advantages, exemplified by defoliation during the Vietnam War (Westing 1971) and the recent deforestation of Turkey's Kurdistan region (van Etten *et al.* 2008). However, in rare instances, military tactics can inadvertently create wildlife habitat. For example, by building ponds to provide soldiers with water, the Chinese military also provided habitat for an endangered turtle (*Mauremys reevesii*) on the Kinmen Islands (Lin *et al.* 2015).

Military tactics often affect wildlife through indirect pathways, which increase the vulnerability of wildlife populations and habitats. Military groups may use protected areas as staging grounds, taking advantage of their remoteness and cover, and their plentiful resources to source food and building materials. Concentrated military activity in areas such as Mozambique's Gorongosa National Park (Hatton *et al.* 2001) and the forests of El Salvador (Hecht and Saachi 2007) has led to habitat degradation and over-

exploitation of wildlife. Furthermore, changes in arms availability alter patterns of wildlife hunting. When guns and other weaponry proliferate, the prevalence and militarization of hunting for meat and other wildlife products increases. During Ethiopia's civil war, guns circulated on the black market and were used to hunt wildlife throughout the country (Jacobs and Schloeder 2001). Conversely, militarization can lead to forced disarmament of local populations by governments and militias, disrupting hunting routines and reducing pressure on local wildlife populations. In Nepal, animals in public forests are thought to have rebounded due to both government and Maoist seizure of arms (Baral and Heinen 2006).

Supporting military activities

Governments and militias raise financial, material, and political support for conflict, and wildlife can play a direct role in providing such support. Bushmeat or high-value wildlife products – notably “conflict ivory” – have financed conflicts throughout Central Africa (Beyers *et al.* 2011). Militaries around the world also harvest wildlife species to feed combatants, targeting traditional food sources such as ungulates, primates, and fish (Nellemann *et al.* 2010). As armies move across landscapes in large numbers, overharvesting can

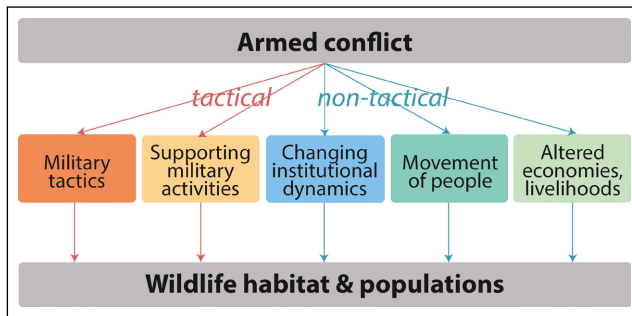


Figure 2. Armed conflict leads to important institutional, economic, and social changes that affect wildlife in diverse ways. Tactical pathways, related to military tactics and raising support for military activities, arise directly from conflict. Non-tactical pathways develop as a result of changing institutional dynamics, movement of people, and altered economies and livelihoods. Within these five categories, we classified 24 specific pathways (Table 1) through which societal outcomes of conflict affect wildlife habitats and populations.

lead to local, regional, or national collapse of wildlife populations (Hatton *et al.* 2001).

The need to support military activities may affect wildlife through the politicized targeting or preservation of important species or habitats. In 2007, Congolese rebels threatened to kill gorillas in Virunga National Park if officials retaliated against rebel advances (Wadhams 2007). Alternatively, some combatants have sought international sympathy through declarations of protection for sensitive ecosystems in Colombia (Dávalos 2001) and endangered species like northern white rhinoceros (*Ceratotherium simum cottoni*) in the Democratic Republic of the Congo (DRC; Anthony 2006).

Changing institutional dynamics

Conflict alters the operation of institutions, including state and local governments, nongovernmental organizations (NGOs), park managers, and research organizations. Institutional capacity to support and manage conservation-related activities is greatly reduced during conflicts, and institutions are largely unable to enforce laws and regulations governing natural resource use. In the Okapi Reserve in the DRC, park guards were forced to abandon their posts following attacks and were unable to prevent elephant and bushmeat poaching (Beyers *et al.* 2011). Similarly, the inability of the Colombian state to assert power in rebel-controlled forests led to increased deforestation and forest fragmentation (Álvarez 2003).

Domestic support for conservation and research typically declines during wartime, and international allies frequently withdraw, leaving parks and wildlife vulnerable. In Sudan, concerns over safety risks for fieldworkers, project feasibility, and potential government resistance impeded the

activities of international conservation-oriented NGOs (Siddig 2014). Institutional capacity may be weakened for years following a conflict. Ethnic Albanians in Kosovo were barred from higher education, leaving few people with adequate training to conduct research and a deprioritization of biodiversity conservation (ARD-BIOFOR 2003). At a local scale, militarization, migration, and economic turmoil disrupt traditional community institutions. In Afghanistan's eastern forests, conventional resource management practices collapsed during 30 years of conflict (Stevens *et al.* 2011b). Such institutional collapses create major challenges to post-war conservation efforts and exacerbate the effects of other negative pathways linking war to wildlife (Shambaugh *et al.* 2001).

Movement of people

Conflict often causes unprecedented movement of civilians, occurring over days or decades, spanning local to international relocations, and resulting in diffuse settlements and dense "camps". Globally, the movements of the world's 32.3 million internally displaced peoples (IDPs) and 14.4 million refugees (UNHCR 2015) inevitably affect wildlife, as large groups of people turn to scarce resources for survival both en route to and once settled in new regions. Displaced people's reliance on wild-caught meat has been documented in Tanzania, where bushmeat hunting is widespread among refugees from conflicts in Rwanda, the DRC, and Uganda (Jambiya *et al.* 2007). Similarly, displaced people frequently overharvest wood for fuel or construction material, as observed near Afghan refugee settlements in Pakistan (Allan 1987) and around tiger reserves in India (Velho *et al.* 2014). Concentrated settlements of refugees and IDPs have major environmental effects that are often far-reaching in time and distance from conflict sites (eg Rwandan refugees in the DRC's Virunga and Kahuzi-Biega parks; Sato *et al.* 2000).

Displacement of peoples by armed conflict can sometimes have positive consequences for biodiversity. Wildlife can be protected when people avoid or flee areas of violence or militarization (Martin and Szuter 1999). A classic example of this "refuge effect" is the unpopulated Demilitarized Zone between North and South Korea, which has hosted flourishing natural habitat and wildlife populations since 1953 (Kim 1997). Such wildlife "refuges" can also arise as a result of reduced hunting pressure; in Zimbabwe, fear of armed forces kept elephant poachers out of many remote areas (Hallagan 1981).

Altered economies and livelihoods

Armed conflict reshapes patterns of resource extraction and wildlife harvest through widespread changes in surrounding economies. At large scales, regional and international trade routes can be altered. For example, American soldiers stationed in Afghanistan established new wildlife trade routes by purchasing and transporting

furs and other products (Kretser *et al.* 2012). Trade routes often close during armed conflict; the cross-border bushmeat trade from Sierra Leone to Liberia was halted when dangerous road conditions reduced hunting in the Gola Forest (Lindsell *et al.* 2011). Armed conflict also affects large-scale extractive industries, such as logging or mining, with direct consequences for wildlife habitat (UNIFTPA 2012). Conflict can disrupt resource extraction, as in Nicaragua, where violence in the 1980s led to the withdrawal of multinational timber companies (Kaimowitz and Fauné 2003). In other cases, conflict leads to intensification of resource extraction to fund militaries (Nellemann *et al.* 2010) or drive post-war development (Le Billon 2000).

At a local scale, war drastically alters civilian livelihoods, as conflict disrupts local industry, trade, and settlement, and generates market shortages and uncertainty. People in conflict areas have less opportunity and incentive to engage in livelihoods that require long-term investments, such as commerce, agriculture, or pastoralism, increasing reliance on natural products with shorter time frames for consumption or sale. Increased offtake of wild meat and fish, wildlife products, fuelwood, and non-timber forest products has been documented throughout Africa's conflict-ridden Great Lakes region (Lanjouw 2003). Furthermore, a decrease in conservation and ecotourism-linked industries during wartime reduces incentives for local conservation (Baral and Heinen 2006).

■ Trends from case studies

Pathway trends

Although biases in research, conservation, and data availability likely affect the discussion of various pathways in the literature, and case studies are not independent, some clear trends emerge. Of 144 studies, the most commonly cited ways in which armed conflict affected wildlife related to social, institutional, and economic changes, rather than tactical aspects of the conflict (Figure 3). Non-tactical pathways, involving changes in institutions, movement, and economies, frequently extended far beyond the conflict in space and time, disrupting all aspects of human society and imposing far-reaching effects on wildlife. By far the most common pathway was weakened institutional enforcement, cited in approximately one-half of the case studies.

Case studies published to date suggest armed conflict has generally negative effects on wildlife habitats and populations. However, an absence of data often precludes assessment of the nature and magnitude of the impact of armed conflict on wildlife, and we must therefore rely on circumstantial evidence to infer outcomes. Ninety-four percent of case studies cited at least one pathway leading to negative outcomes for wildlife, whereas only 33% cited a positive pathway. Overall, the

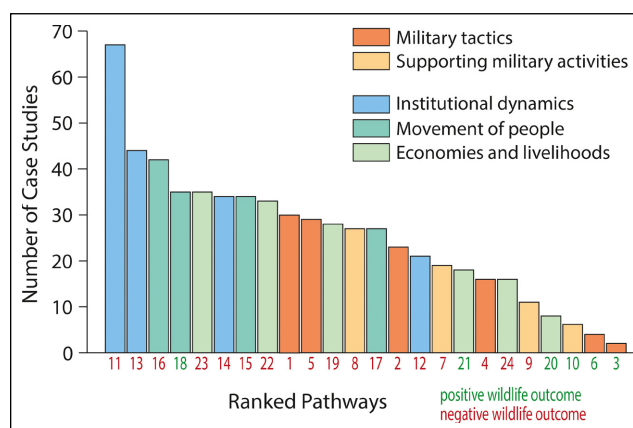


Figure 3. Number of case studies citing each of the 24 pathways linking armed conflict to changes in wildlife populations or habitat. Pathways are identified by their numbers from Table 1. Pathways associated with non-tactical pathways were generally cited more often than tactical pathways associated directly with war activities. Pathways with positive impacts on wildlife were far less common than pathways with negative impacts, with the exception of the refuge effect (pathway 18).

18 negative pathways were cited much more often than the six positive pathways, with the exception of the refuge effect (Figure 3).

Geographic patterns

Regional trends arise from differences in conservation concerns and conflict patterns, including duration of conflict and actors involved (Panel 1; Pettersson and Wallenstein 2015). In Africa, the most-studied region, decreased enforcement of park and poaching regulations are a particular challenge. Notably, African militias often rely on bushmeat and other natural resources (Shambaugh *et al.* 2001). Charismatic African megafauna like gorillas and elephants have long attracted conservation interest, contributing to the heavy representation of African conflicts in the literature linking wildlife and conflict, and to the politicization of wildlife during war.

The high representation of non-tactical pathways in both Africa and Latin America, particularly relating to the movement of people, reflects the protracted nature of many decades-long conflicts between governments and internal opposition groups (WebTable 1). In Latin America, most case studies address habitat outcomes rather than wildlife, reflecting a regional emphasis on forest research and conservation (Stevens *et al.* 2011a). While many case studies document forest loss, the refuge effect also emerges as a common pathway in the region, slowing wildlife declines during long periods of war (Álvarez 2003).

The leading pathways in the Middle East case studies relate to military strategy, probably due to the nature of the associated conflicts. One-half of the Middle Eastern case studies involve conflicts between states, and these

Panel 1. Geographic patterns

Case studies represented a range of armed conflicts around the world (Figure 4), with most studies focusing on Africa ($n = 67$ cases, 14 unique conflicts), Asia ($n = 48$ cases, 13 conflicts), and the Middle East ($n = 17$ cases, 8 conflicts). Pathways linking armed conflict to wildlife outcomes vary across regions (Figure 5).

Common pathways in each region:

Africa

- (1) Enforcement abilities decrease ($n = 40$ case studies)
- (2) Displaced people harvest natural resources ($n = 29$)
- (3) Displaced people kill wildlife for food ($n = 28$)

Asia

- (1) Enforcement abilities decrease ($n = 21$)
- (2) Refuge effect (people avoid conflict areas) ($n = 15$)
- (3) Conservation and research activities decline AND new trade routes for wildlife, natural resources ($n = 13$)

Middle East

- (1) Mines, bombs, and chemicals kill wildlife ($n = 11$)
- (2) Environment altered as war tactic ($n = 6$)

Latin America

- (1) Refuge effect (people avoid conflict areas) ($n = 7$)
- (2) Extractive industries expand ($n = 6$)

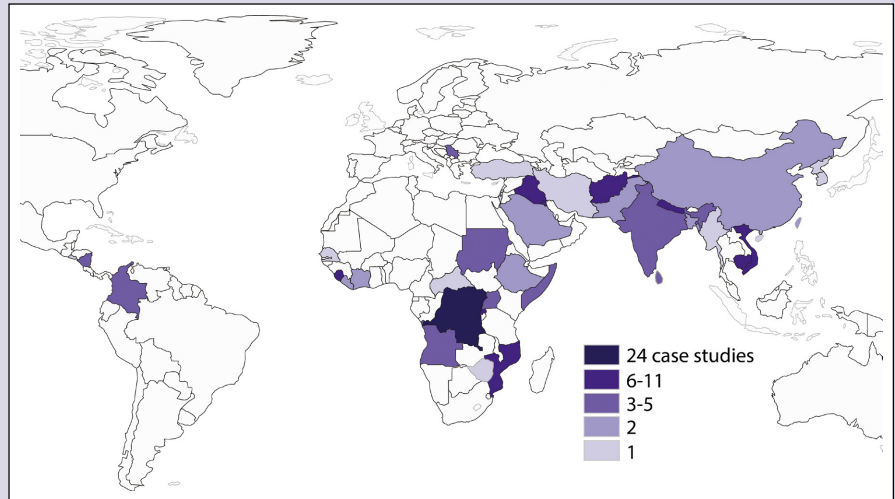


Figure 4. The academic and gray literature on armed conflict and wildlife drew on case studies from around the world, although there was much greater representation of certain regions (eg Africa, Asia, and the Middle East) and countries (eg the Democratic Republic of the Congo).

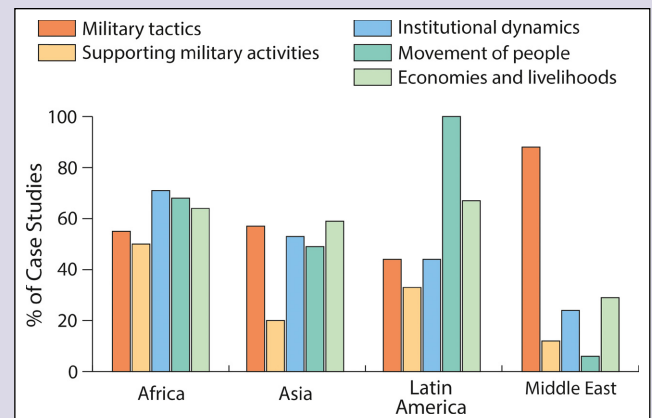


Figure 5. Pathways related to supporting military activities were more prevalent in Africa than in other regions, and pathways arising from military tactics were overwhelmingly dominant in the Middle East. Non-tactical pathways were cited frequently in case studies from Africa, Asia, and Latin America.

tend to be shorter and more isolated, and involve more environmentally destructive tactics (WebTable 1). Contemporary Middle Eastern conflicts between states and internal rebel organizations are diffuse and long-lasting, and likely generate a diversity of non-tactical pathways; however, these conflicts have not yet been addressed in the literature. Asia has seen a diversity of conflict types, including internal, interstate, and internationalized conflicts, and conservation in the region emphasizes both forests and wildlife (WebTable 1). As such, no distinctive trends emerged from the literature. There is insufficient representation of European conflicts to identify regional patterns.

Taxonomic patterns

Armed conflict has differential effects across animal taxa (Panel 2). Mammals are particularly vulnerable to changes in hunting pressure, and hunting increases with weakened enforcement and with movement and armament of people. Mammals were also often targeted to raise financial support for military activities, given the high value of mammal products such as ivory and fur, and the politicized aspects of mammal conservation. In contrast, birds, fish, reptiles, amphibians, and invertebrates were more likely to be indirectly affected through habitat change, when conflict

Panel 2. Taxonomic patterns

Most case studies (63%, $n = 91$) focused on the effects of armed conflict on multiple wildlife species, 17% focused on a single species ($n = 24$), and 20% considered the extent of wildlife habitat ($n = 29$).

Among the 115 wildlife-focused studies (single and multiple species), 78% ($n = 81$) discussed mammals (particularly ungulates and primates), while 42% ($n = 48$) discussed non-mammalian taxa, including birds (22%), fish (19%), reptiles/amphibians (8%), and invertebrates (1%). Mammals and non-mammals experienced different effects of armed conflict (Figure 6).

Common pathways by taxon:

Mammals

- (1) Enforcement abilities decrease ($n = 48$)
- (2) Conservation and research activities decline ($n = 33$)
- (3) Displaced people harvest natural resources ($n = 29$)

Non-mammals

- (1) Mines, bombs, and chemicals kill wildlife, environment altered as war tactic, enforcement abilities decrease, AND traditional natural resource management weakened ($n = 15$)

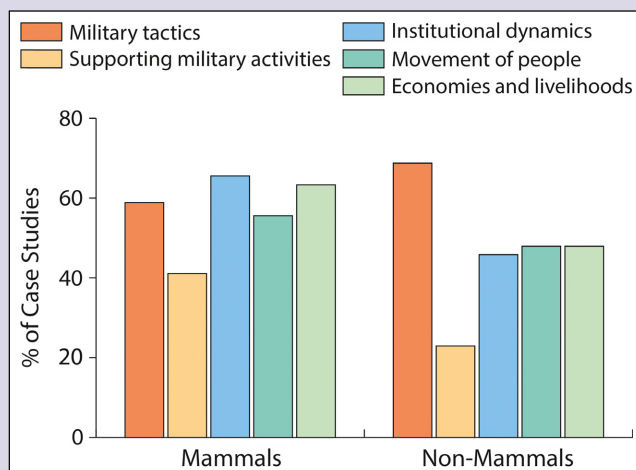


Figure 6. Taxonomic patterns emerged among pathways linking war to wildlife. Non-mammals were more often affected by military tactics, while mammals were more likely to be implicated in supporting military activities and affected by non-tactical aspects of conflict.

altered the environment (eg chemicals, mines) and disrupted livelihoods and traditional resource management practices.

Mammals, and particularly charismatic megafauna, were highly represented in the literature, and many single-species studies focused on great apes and elephants. This bias favors species with high conservation priority and trade value over others of local or ecological importance, and thereby hinders our ability to understand how conflict affects biodiversity in a broader sense. Furthermore, a focus on a single species or taxon may obscure taxonomic differences in pathway responses, overlooking the importance of ecological interactions. A pathway or outcome that is “positive” for a charismatic species might be detrimental for others; during Zimbabwe’s civil war, the refuge effect reduced elephant poaching, but subsequent elephant overpopulation led to the destruction of woodland habitat upon which other species relied (Hallagan 1981).

Discussion

Interactions among pathways

The pathways linking armed conflict to wildlife cannot be considered in isolation. Many case studies documented complex conflict dynamics, with an average \pm standard deviation of 4.2 ± 2.8 pathways per case. Pathways often act in conjunction with one another to amplify or offset the effects of conflict on wildlife. In the DRC, decreased enforcement facilitated new trade routes for smuggled natural resources, financing

militias and enabling them to obtain arms, access wildlife hotspots, and drive local human migration (Nellemann *et al.* 2010). In Afghanistan, increased reliance on natural food sources, coupled with weakened enforcement and readily available weapons, led to rampant wildlife harvest and decline (Saidajan 2012). Yet synergistic outcomes can sometimes be positive for wildlife, as in Nicaragua, where the relocation of people from war zones (a refuge effect), combined with a decline in large-scale extractive industries, enabled recovery of wildlife populations and habitats (Nietschmann 1990). In other cases, one pathway may counteract the effects of another. In Serbia, police prevented armed hunting in previously hunted regions, but then hunted wildlife themselves (ARD-BIOFOR 2003).

Pathways span temporal and spatial scales, and positive outcomes for wildlife in one place or time can coincide with negative outcomes elsewhere, as people and institutions shift during wartime. The refuge effect is commonly cited as beneficial for wildlife, as conflict-related risk keeps people away from wildlife habitat and limits hunting and habitat degradation (Dudley *et al.* 2002). Nevertheless, displaced people may simply move to other areas, where increased hunting and resource harvest pressure compromises different populations and habitats (Draulans and van Krunkelsven 2002). In Colombia, while large swaths of forest were relatively protected by the guerillas that occupied them, overall forest cover fell dramatically as agricultural conversion was concentrated in spaces outside guerilla-dominated forests (Álvarez 2003).

Research challenges and recommendations

Biological research is usually deprioritized in conflict areas, given the threats to personal safety and lack of financial and institutional support. As a result, there is a paucity of data on trends pertaining to wildlife populations and habitats in conflict areas, and it is difficult to accurately assess the impacts of conflict on biodiversity generally and wildlife specifically. Furthermore, given the complexities inherent to conflict, it is difficult to ascribe broad wildlife outcomes to particular pathways. However, for a given conflict, the elucidation of relevant pathways and their interactions is a critical first step to mitigating environmental harm.

The 144 case studies we reviewed used a range of approaches to clarify the linkages between armed conflict and wildlife, from observations and anecdotes to detailed interviews and surveys of key participants, as well as broader-scale investigations of history, anthropology, political economy, and ecology (WebTable 1). To assess outcomes, the authors of some case studies were able to draw on pre-conflict census and survey data, like the studies of faunal consequences of the Gulf War oil spill (eg Price *et al.* 1994), but such baseline information and immediate monitoring was absent in most cases (Bhatnagar *et al.* 2009). To overcome data limitations, many case studies combined multiple sources and used a mix of biological and social data to elucidate wildlife outcomes (Sahoo *et al.* 2013) and identify the pathways that underlie them (Allan 1987; Baral and Heinen 2006; Loucks *et al.* 2009). Even though conflict cannot always be predicted, the collection of basic wildlife survey and census data throughout areas of conservation concern can provide valuable baseline information in the event of armed conflict. Additionally, remote sensing is an increasingly powerful tool to evaluate conflict impacts at lower cost and risk (eg Nackoney *et al.* 2014), although the most robust studies supplement satellite imagery with on-the-ground investigations (Gorsevski *et al.* 2013) and assessments of wildlife populations.

Given the heterogeneity of conflicts and their effects, context-specific research should use all available data sources to infer salient pathways and outcomes for a given region. Such interdisciplinary studies are essential in understudied regions, conflicts, and taxa. Targeted research should also explore common pathways, particularly those related to institutions and natural resource use. A better understanding of the mechanisms through which non-tactical aspects of conflict affect societal dynamics, and how these dynamics in turn affect wildlife, will enable more informed interventions and mitigation strategies. Meanwhile, continuing to recognize trends across regions and species will allow scientists and managers to better understand and anticipate the effects of armed conflicts.

Management implications

Conservation practitioners can mitigate the consequences of conflict by targeting specific pathways. In particular, conservation organizations should focus on pathways that are most feasible to address given their expertise, while supporting peacekeeping and development organizations in addressing other aspects of conflict. An assessment of the DRC's Garamba National Park found links between war and increased bushmeat hunting but, unexpectedly, found that anti-poaching patrols had been consistently maintained throughout the conflict (de Merode *et al.* 2007). In this case, strengthening enforcement in the park may not be as effective as leveraging support, information, and access for organizations that address food security issues or supply chains.

In most cases, it will be challenging for conservation practitioners to alter tactical pathways that arise from conflict, given that battlefield success will take priority over conservation concerns (Shambaugh *et al.* 2001). Realistically, many of the outcomes of the tactical pathways are best addressed through post-war disarmament and environmental remediation. Yet some negative impacts on wildlife can be mitigated by strengthening institutions that manage the environment before, during, and after conflict (Unruh *et al.* 2008). Although conflicts are often accompanied by the weakening of state institutions, there may be opportunities for local civil society, perhaps with support from external allies, to fill institutional gaps during and after conflict and support state peace-building processes (Plumptre *et al.* 2016).

Practitioners must take a pragmatic approach when addressing links between war and wildlife by identifying desired outcomes and trade-offs. Even where research suggests conflict confers short-term benefits to wildlife, those benefits may belie opposing long-term trends or other undesired consequences. During Sierra Leone's civil war, violence and lack of institutional support for the fisheries sector may have benefitted fish populations but was detrimental to the livelihoods of artisanal fishers (Thorpe *et al.* 2009); here, a closely monitored, sustainable fishery during and after conflict would provide for both conservation and development concerns. Trade-offs also exist in the context of conservation prioritization: given limited funding and resources, conflict-free areas may be prioritized for interventions over war-torn areas. However, wildlife and natural resource conservation is critical not only for safeguarding biodiversity but also for maintaining ecosystem services and local livelihoods for vulnerable human populations.

Conclusions

By enumerating and exploring trends in the linkages between armed conflict and wildlife, we provide a framework for considering the intricacies of conflict and wildlife outcomes. There remain many challenges to understanding and addressing these links, not least

of which are the logistical and ethical difficulties of conducting and advocating conservation work in conflict areas. The tragic reality of conflict within biodiversity hotspots necessitates a greater understanding of the complex dynamics affecting people, wildlife, and ecosystems in these regions.

Our literature review is a first step, and further empirical work is needed to outline strategies for mitigating the effects of conflict on wildlife. This research should be interdisciplinary, collaborative, and innovative, acknowledging the nuances and diversity of conflict types, regions, and wildlife taxa. From this renewed understanding, conservation managers and partners can begin to test and implement a set of strategies that directly mitigate the impacts on wildlife and their habitats. The further development of conservation expertise in pre- and post-conflict situations and greater support for recovering institutions and governments are vital in securing the persistence of wildlife populations in conflict-torn regions.

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